

## Chapter 6

### Special Detailing Requirements and Other Design Considerations

#### 6-1. Introduction

After the general arrangement of the intake structure has been determined, access, openings, and operational and maintenance provisions should be developed to provide a functional project.

#### 6-2. Access Bridge Requirements

*a. General.* Where necessary, a service bridge extends from the top of the dam or from the valley wall to the intake tower to provide access for the operation, repair, and maintenance of the gates, equipment, and appurtenances. A single-lane access bridge is sufficient. The bridge is designed for the AASHTO standard truck loading and for all possible off-highway loads due to cranes lifting or transporting gates or other equipment into or out of the intake tower. The designer should thoroughly investigate the methods used to transport and remove or install gates to make sure that all possible bridge loadings have been accounted for in the design. Generally, a single-span bridge is most economical due to the high costs of constructing intermediate supporting piers. The single spans may be prestressed girders, rolled steel beams, welded plate girders, or steel trusses. Prestressed concrete girders and rolled steel girders are economical for spans up to 110 ft. Welded plate composite steel girder bridges are commonly used for spans from 110 to 175 ft and have been used for spans up to 350 ft. However, steel trusses or intermediate piers should be considered when spans exceed 175 ft. The engineer should determine whether it is best to accommodate expansion at the abutment end or tower end of the bridge. Attaching the bridge at the tower with a fixed bearing prevents the tower and bridge from hammering during an earthquake. All bearings should have adequate seat widths and restraints to prevent loss of support during an earthquake. When the bridge is attached to the intake tower with a fixed bearing, the bridge and tower should be combined in a single analytical model to determine the combined effects of the bridge tower system when subjected to the design earthquake ground motions. The bridge superstructure will normally be capable of withstanding all the seismic inertial forces without difficulty. The objectives of the seismic analysis are to ensure that the bridge bearings and supports can accommodate the seismic inertial forces and displacements and that the supporting piers, abutments, and their foundations can accommodate the seismic inertial forces.

*b. Load criteria.* The bridge should be designed to withstand safely all group combinations of forces in AASHTO that are applicable. The bridge should be designed by load factor design methods using the appropriate load factors and strength reduction factors in AASHTO. The design for earthquake loadings should employ the response spectrum methodology with the earthquake demands in accordance with those established for the dam and intake tower. Impact may be omitted except when a mobile crane or gantry crane is used to pick up a gate from the bridge. When it is anticipated that construction equipment will have to use the bridge, the bridge shall be designed to accommodate construction load conditions.

#### 6-3. Tower Service Deck Requirements

*a. General.* Simplicity and economy are the primary considerations in design of the intake tower service deck. Although the intake structure is essentially a reinforced concrete structure, economy may be affected and construction simplified by the use of steel beams in the operating and service decks, steel roof joists, etc.

*b. Load criteria.*

(1) The service deck at the top of the intake structure should be designed to withstand 250 lb/ft<sup>2</sup>, or a loaded crane or truck, whichever controls. The removable hatch covers and openings should be protected by a structural steel frame. All edges exposed to traffic and heavy equipment should have armor angle protection.

(2) Intake structures with gate hoisting equipment on the operating deck are designed for the loads of the gate hoists with maximum gate operating loads. The floor slab between hoists should be designed for a uniform load of 250 lb/ft<sup>2</sup> unless a different load is warranted. The service deck should be designed for the concentrated dead load of a service gate in each service gate opening or the emergency gate in any emergency gate opening and supported by logs or blocking at the edge of the opening. The house above the operating deck is designed according to usual load and stress criteria for buildings unless a different load is warranted.

#### **6-4. Concrete Temperature Control Measures**

Cracking occurs when tensile stresses within the concrete exceed the tensile strain capacity of the concrete. In mass concrete, primary stresses result from volume changes that occur as the concrete cools from its initial peak temperature down to ambient air temperature. If not controlled or limited to acceptable levels, the tensile stresses will quickly exceed tensile strain capacity of the concrete and result in unacceptable cracking. Measures can be taken to prevent the tensile stresses from exceeding acceptable values only after the tensile strain capacity of the concrete has been determined. To achieve proper temperature control, the designer must determine various thermal properties for both the aggregates and the concrete. These properties include thermal conductivity, diffusivity, specific heat of hydration, coefficient of thermal expansion, etc. After the tensile strain capacity of the concrete and the amount of thermal contraction that can occur without causing cracking have been determined, specific measures can be taken to limit the initial peak temperature. One measure is to reduce concrete placement temperatures, and thereby lower final peak concrete temperatures. Other measures can be taken (individually or in combination) that will be successful in controlling temperature gains sufficiently to reduce or prevent cracking. Some of these measures are as follows: reducing Portland cement contents, use of fly ash as Portland cement replacement, use of chilled water or ice to reduce initial concrete placement temperature, provision of postcooling techniques such as using cooling coils, cooling aggregate stockpiles, using the largest size aggregate practical, placement of concrete in thinner lifts, and/or extending intervals between concrete placements. For additional discussion on crack control, see ACI 224R-90 Committee Report, and ETL 1110-2-365, "Nonlinear Incremental Structural Analysis of Massive Concrete Structures."

#### **6-5. Air Vents**

Circular or rectangular air vents are placed at the downstream side of the service gates to reduce cavitation damage and prevent erratic flow conditions. Vents are extended above pool elevations, preferably above the spillway design flood pool, and are arranged to open outside the structure far enough away from the service bridge or any platform where personnel could possibly be endangered by the strong inflow of air during outlet operation. When convenient and economical, the air vents from two or more gates may be brought together at a point above the pressure gradient into a larger vent. Vents may be steel pipes or may be formed in concrete. Appropriate air venting should also be provided for dewatering and filling operations downstream of valves, bulkheads, and stoplogs in water passages. EM 1110-2-1602, Chapter 3, provides pertinent information on how to size and determine the locations of air vents.

## 6-6. Abrasion- and Cavitation-Resistant Surfaces

*a. General.* Consideration should be given to all water surfaces in the structure that may be subject to abrasion resulting from sediment flow and potential cavitation caused by high velocities and surface irregularities. All operating conditions, including diversion, should be evaluated for potential adverse effects.

*b. Provisions for abrasion and cavitation protection.* For concrete surfaces, the use of stainless steel linings, special concrete, abrasion-resistant coatings, and special concrete specifications to provide a high quality surface may be necessary to attain the required protection. Special concretes may include special aggregate concrete and silica fume concrete. Areas in the concrete specifications that should be addressed include the use of steel forms, additional forming support, restrictions on form joint locations, tighter surface tolerances, placement sequencing, prohibiting positive projections into the flow, and required submittals for critical concrete operations.

*c. Repair.* Specific methods for concrete repairs, patching, and grinding for construction deficiencies should be clearly defined in the specifications. Typical repair methods may not be satisfactory to provide the desired long-term durability. Repairs in high-velocity areas may require excavation to a depth that will allow bonding of the patch to the near-face reinforcement.

## 6-7. Corrosion Control

Gates, liners, piping, and other ferrous equipment and materials shall be protected against corrosion by coating and/or cathodic protection. For further information refer to UFGS 09965A, Painting: Hydraulic Structures; UFGS 09971A, Metalizing: Hydraulic Structures; TM 5-811-7, Electrical Design, Cathodic Protection; and the U.S. Army Construction Engineering Research Laboratory paint lab, Champaign, IL.

## 6-8. Operations and Maintenance Considerations

An important operation and maintenance consideration for a newly constructed intake structure is to minimize staffing requirements. To accomplish this objective, a remote control system and automated surveillance systems should be considered. To reduce maintenance, materials should be selected with extended service life in mind. The materials selected should resist corrosion and abrasion and minimize periodic maintenance. Features needed for maintenance should be provided including the maintenance bulkheads and bulkhead slots required for the on-site maintenance of emergency and service gates.

## 6-9. Instrumentation

Structural behavior instrumentation programs are provided for intake structures to measure the structural integrity, check design assumptions, and monitor the behavior of the foundation and structure during construction and the various operating phases. The extent of instrumentation at projects will vary depending on particular site conditions, the size of the structure, and needs for monitoring critical sections. Instrumentation can be grouped into those that either directly or indirectly measure conditions related to the safety of the structure. Plumbness, alignment, uplift, and seismic instruments fall into the category of safety instruments. In the other group, the instruments measure quantities such as stress and strain, length change, pore pressure, leakage, and temperature change. EM 1110-2-4300 provides details and guidance on the planning of instrumentation programs, types of instruments, and the preparation, installation, and collection of data.